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RESEARCH MEMORANDUM

for the

U. S. Air Force

WIND-TUNNEL TESTS OF A SERIES OF PRACTICE BOMBS

COORD. NO. AF-247

By Donald H. Ward

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Langley Field, Va.

NATIONAL ADVISORY COMMITTEE
FOR AERONAUTICS

WASHINGTON

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SUMMARY

Zero-lift drag data were obtained for several practice bomb configurations at Mach numbers from 0.60 to 1.10. The seven configurations tested were different combinations of interchangeable noses and tail cones with fins, and some of these configurations had different model surface conditions. The tests were made in the Langley 8-foot transonic tunnel with the Reynolds number varying from 5.190×10^6 to 6.452×10^6 during the investigation.

The results of this investigation indicate that the surface conditions of the model had no significant effect on the model drag. The thick tail fins which were tested contributed a large portion of the drag throughout the Mach number range; whereas, a set of thin tail fins contributed greatly to the drag only at Mach numbers below 0.95. Two of tne nose shapes tested contributed essentially the same amount to the drag of the model; however, the third nose, which was hemispherical in shape, greatly increased the model drag throughout the Mach number range and changed the shape of the drag curve at Mach numbers from 0.80 to 0.95.

INTRODUCTION

An investigation was conducted in the Langley 8-foot transonic tunnel to determine the zero-lift drag characteristics of a series of Republic Aviation Corporation practice bombs. Three interchangeable nose shapes and a tail cone with two sets of fins were tested to determine the effect of nose shape and of tail fins on the drag of the model.

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Tests were also made to determine the effect of body surface and tail-cone roughness on the model drag. These tests were made at Mach numbers ranging from 0.60 to 1.10 during which the Reynolds number varied from 5.190×10^6 to 6.452×10^6. The tunnel stagnation pressure was 1 atmosphere.

SYMBOLS

M	Mach number
C_D	total drag coefficient, $\frac{\text{Drag}}{qA}$
A	maximum frontal area of model
q	dynamic pressure, $\frac{1}{2}\rho V^2$
ρ	density
V	velocity
R	Reynolds number based on body length
p_b	static pressure at base of model
p_∞	free-stream static pressure
$C_{p,b}$	base pressure coefficient, $\frac{p_b - p_\infty}{q}$

APPARATUS AND METHODS

Tunnel

The Langley 8-foot transonic tunnel has a dodecagonal slotted test section which permits continuous testing through the Mach number range from 0.60 to 1.10. Details of the tunnel design are presented in reference 1. Maximum deviation of the free-stream Mach number is indicated to be no more than ±0.003 from the average in the model test region. The models were sting supported as showr in figure 1 and were attached to the model support system shown in figure 1 of reference 1.

Models

The models tested consisted of one basic body with three interchangeable tail cones (two with fins) and three interchangeable noses. Figure 1 shows the model assembled with nose A and tail C, and figure 2 is a photograph of the three noses and three tail cones. The test configurations are given in table I. Coordinates for all of the noses and the basic body are given in figure 3(a) and the tail-fin dimensions are given in figure 3(b). The nose and basic-body sections were made of aluminum and were finished "as cast" with a maximum surface roughness of 250 root-mean-square microinches. The tail cones and fins were made of aluminum alloy with a smooth machined finish. All fins tested had a sweepback angle of 35°. The thickness ratio for the thin fins was 2 percent and for the thick fins was 4 percent.

The models were mounted on a three-component strain-gage balance from which the drag data were recorded, and a static orifice was located at the base of the model for measuring base pressures.

Tests

In this investigation, each configuration given in table I was tested at Mach numbers of approximately 0.60, 0.70, 0.80, 0.90, 0.925, 0.95, 0.975, 1.00, and 1.10 with the model at 0° angle of attack. Drag data and base-pressure data were recorded at each Mach number.

The tunnel stagnation pressure was 1 atmosphere and the stagnation temperature varied from 114° F to 155° F. The Reynolds number, based on body length, varied from 5.190×10^{6} to 6.452×10^{6} during the investigation. Figure 4 shows the variation of Reynolds number with Mach number for the models tested.

RESULTS AND DISCUSSION

The drag data are presented in coefficient form in figures 5 to 7. The drag coefficient C_D is based on the area of a 3-inch-diameter circle which is the maximum cross-sectional frontal area of the models tested. These coefficients have been corrected to give free-stream conditions at the base of the model. The base pressures used for this correction are presented in figure 8. Based on the balance accuracy, the drag coefficient is estimated to be accurate within ±0.005 at a Mach number of 0.80.

Effect of Nose Shape on Drag

Figure 5 presents the drag curves which show the effect of nose shape on the drag of the model. A comparison of the curves in figure 5(a) indicates that there is no significant change in the drag characteristics of the practice bomb if nose B is used to replace the conventional practice bomb nose (nose A).

Figure 5(b) presents the drag curves for configurations 5 and 6. A comparison of these curves shows the effect of replacing the conventional practice bomb nose (nose A) with a blunt nose (nose C). The blunt nose increases the drag throughout the Mach number range; however, this increase is not significant at Mach numbers 0.70 and below. At Mach numbers from 0.80 to 0.95 the drag of the model with the blunt nose is considerably higher and with a different slope to the drag curve. From Mach numbers 0.975 to 1.10 the slopes of the two curves appear to be about the same although the blunt nose causes an increase in the drag coefficient of approximately 0.07 in this speed range.

Effect of Model Roughness on Drag

The effects of body surface roughness on the model drag may be seen by comparing the curves in figure 6(a). Configuration 6 was tested in the "as cast" condition and configuration 7 was the same model which had been sprayed with glazing putty, fine sanded, waxed, and polished. Since the difference in the drag of these two models is less than the accuracy of the balance, the difference is considered to be insignificant.

The drag curves for configurations 2 and 3 may be seen in figure 6(b). The effect on the drag of configuration 2 due to adding No. 60 carborundum grains to the tail cone may be seen by comparing these curves. Configuration 3 is similar to configuration 2 except for the addition of the carborundum. Considering the accuracy of the results, there is no significant change in the model drag due to the carborundum on the tail cone.

Effect of Tail Fins on Drag

The effect of tail fins on the model drag is shown by comparing the curves in figure 7. The increase in drag due to the thin fins of tail B can be seen by comparing the curves in figure 7(a). Configuration 1 is the basic body with nose A and tail B (thin fins) and configuration 6 is a similar model with no tail fins (tail A). The thin fins caused an increase in drag coefficient in the subsonic range up to Mach number 0.95 of approximately 0.04. From a Mach number range of 0.95 to 1.10 the increment of drag increase due to the thin fins decreases from 0.04 to approximately 0.01.

Drag data for configurations 4 and 5 are presented in figure 7(b). These configurations were essentially the same except for the thick tail fins which were used on configuration 4. A comparison of the curves in figure 7(b) shows the increase in drag of the model with the thick tail fins (tail C). This comparison shows that the thick fins increase the drag coefficient of the model by approximately 0.03 throughout the subsonic range and by 0.06 at Mach number 1.10.

CONCLUDING REMARKS

An investigation was conducted in the Langley 8-foot transonic tunnel to determine the zero-lift drag characteristics of a series of Republic Aviation Corporation practice bombs. The results of this investigation are as follows:

1. The conventional practice bomb nose and the conical nose contributed essentially the same amount to the drag of the practice bomb, whereas a blunt nose greatly increased the drag at Mach numbers above 0.70 with a particularly large increase at a Mach number of 0.90.

2. The surface roughnesses tested had no significant effect on the drag of the model.

3. The thin tail fins contributed a large part of the drag at Mach numbers below 0.95; however, the additional drag due to the thin fins at supersonic speeds was small.

4. The thick tail fins contributed a large part of the drag throughout the Mach number range.

Langley Aeronautical Laboratory,
National Advisory Committee for Aeronautics,
Langley Field, Va., October 1, 1957.

Donald H. Ward
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Aeronautical Research Engineer

Approved: Eugene C. Draley
Eugene C. Draley
Chief of Full-Scale Research Division

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REFERENCE

1. Ritchie, Virgil S., and Pearson, Albin O.: Calibration of the Slotted Test Section of the Langley 8-Foot Transonic Tunnel and Preliminary Experimental Investigation of Boundary-Reflected Disturbances. NACA RM L51K14, 1952.

TABLE I

TEST CONFIGURATIONS

Configuration	Nose	Tail	Remarks
1	A	B	Tested as manufactured
2	B	B	Tested as manufactured
3	B	B	Tail cone heavily coated with No. 60 carborundum grains
4	C	C	Tested as manufactured
5	C	A	Tested as manufactured
6	A	A	Tested as manufactured
7	A	A	Model surface smooth*

*Model surface was sprayed with glazing putty, fine sanded, waxed, and polished.

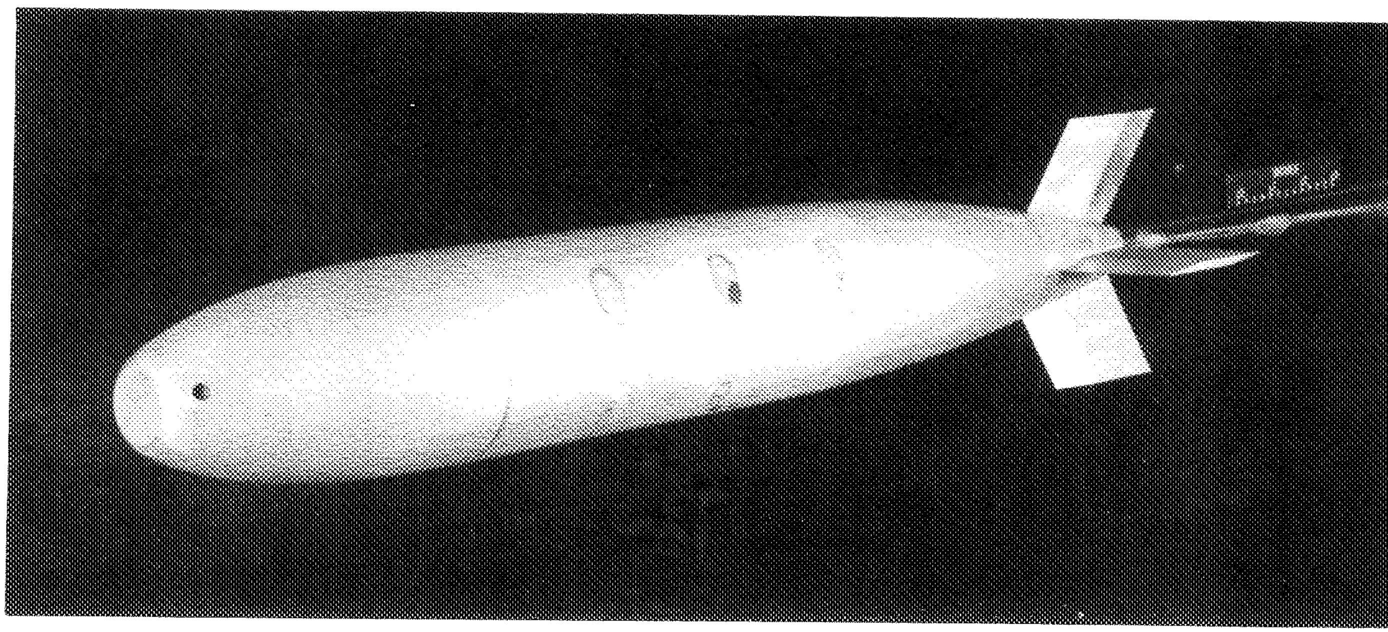
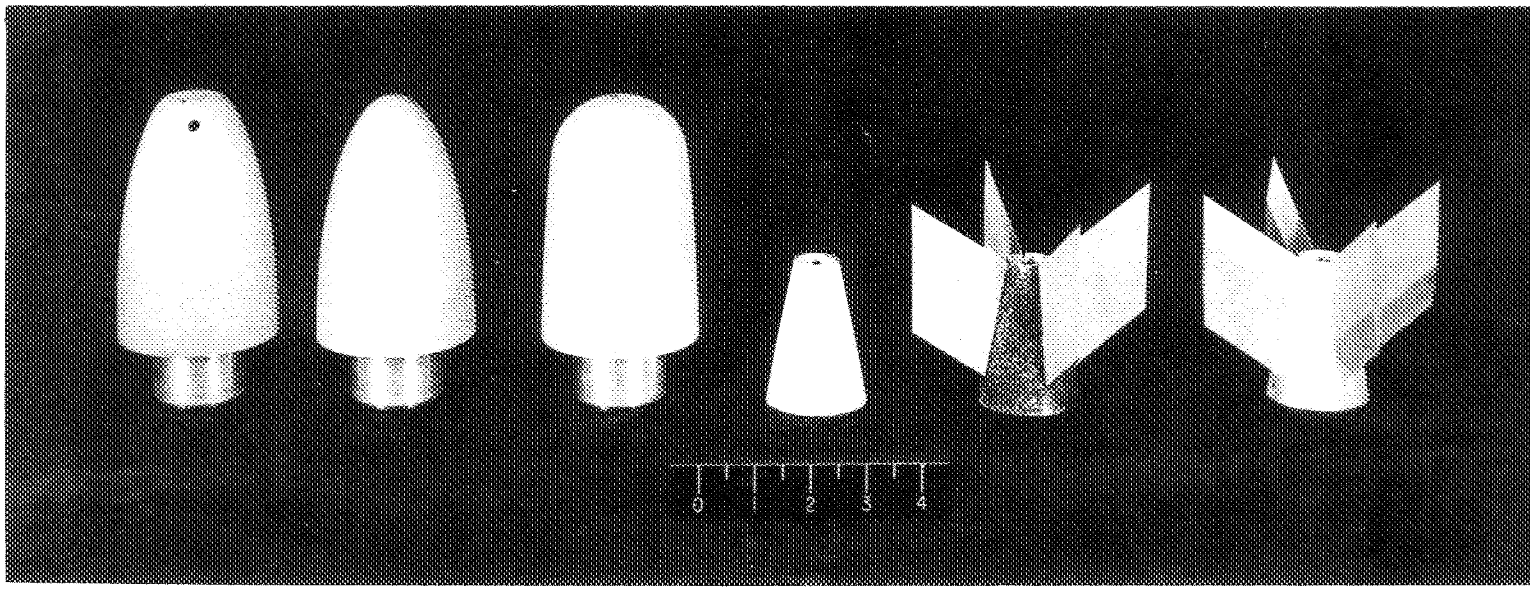


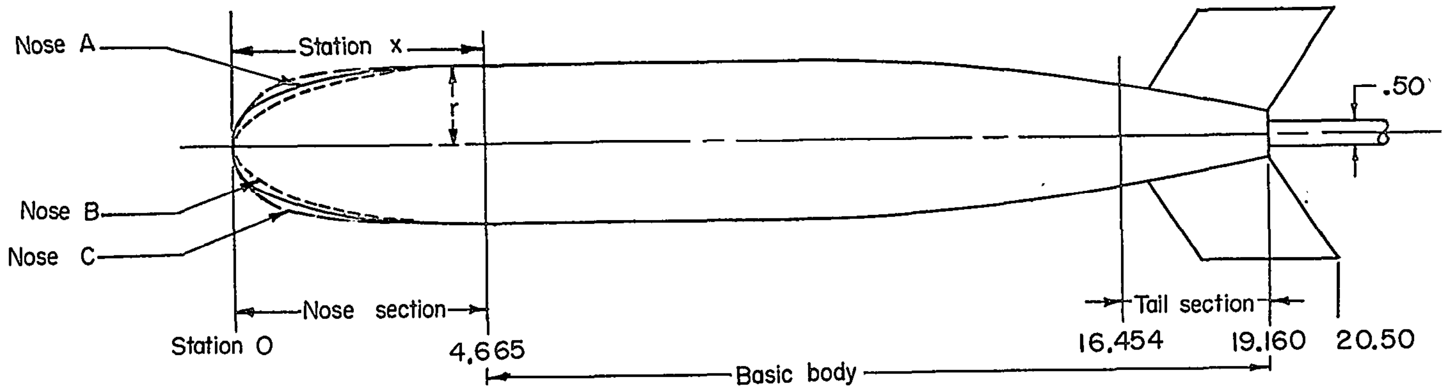
Figure 1.- Model configuration mounted on sting. L-89860



A B C A B C

Noses Tails

Figure 2.- Nose and tail configurations. L-89859.1



Basic-body coordinates					
Station x	Radius, r	Station x	Radius, r	Station x	Radius, r
4.665	1.500	14.015	1.319	17.638	0.742
10.762	1.500	14.829	1.220	18.083	.650
11.576	1.488	15.642	1.095	18.895	.481
12.388	1.454	16.454	.966	19.160	.427
13.201	1.397	17.269	.816		

Nose coordinates					
Nose A		Nose B		Nose C	
Station x	Radius, r	Station x	Radius, r	Station x	Radius, r
0	0.529	0	0	0	0.200
.10	.608	.12	.338	.05	.404
.30	.736	.24	.475	.10	.533
.60	.886	.30	.529	.25	.783
1.10	1.071	.40	.608	.50	1.032
1.60	1.208	.60	.736	.75	1.178
2.04	1.300	.90	.886	1.00	1.262
2.52	1.378	1.40	1.071	1.25	1.311
2.98	1.432	1.90	1.208	1.50	1.344
3.44	1.470	2.34	1.300	2.00	1.386
4.24	1.499	2.82	1.378	2.50	1.419
4.365	1.500	3.28	1.432	3.00	1.444
		3.74	1.470	3.50	1.465
		4.54	1.499	4.00	1.483
				4.50	1.498

Note: All dimensions in inches except as noted.

(a) Basic body and noses.

Figure 3.- Details of models.

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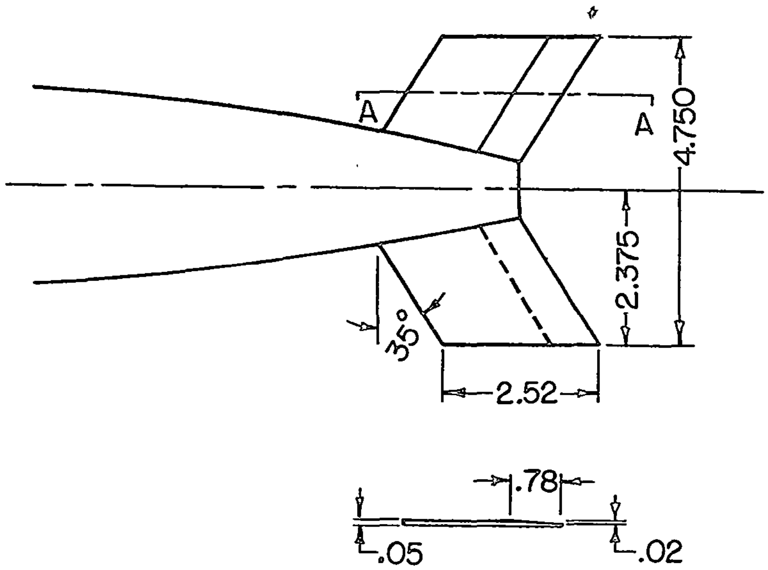
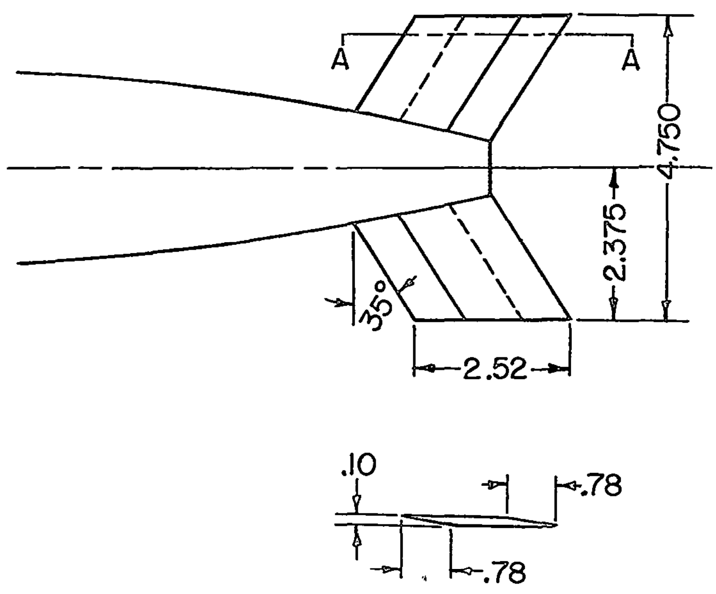


Details of tail fins for tail B



Details of tail fins for tail C

(b) Tail fins.

Figure 3.- Concluded.

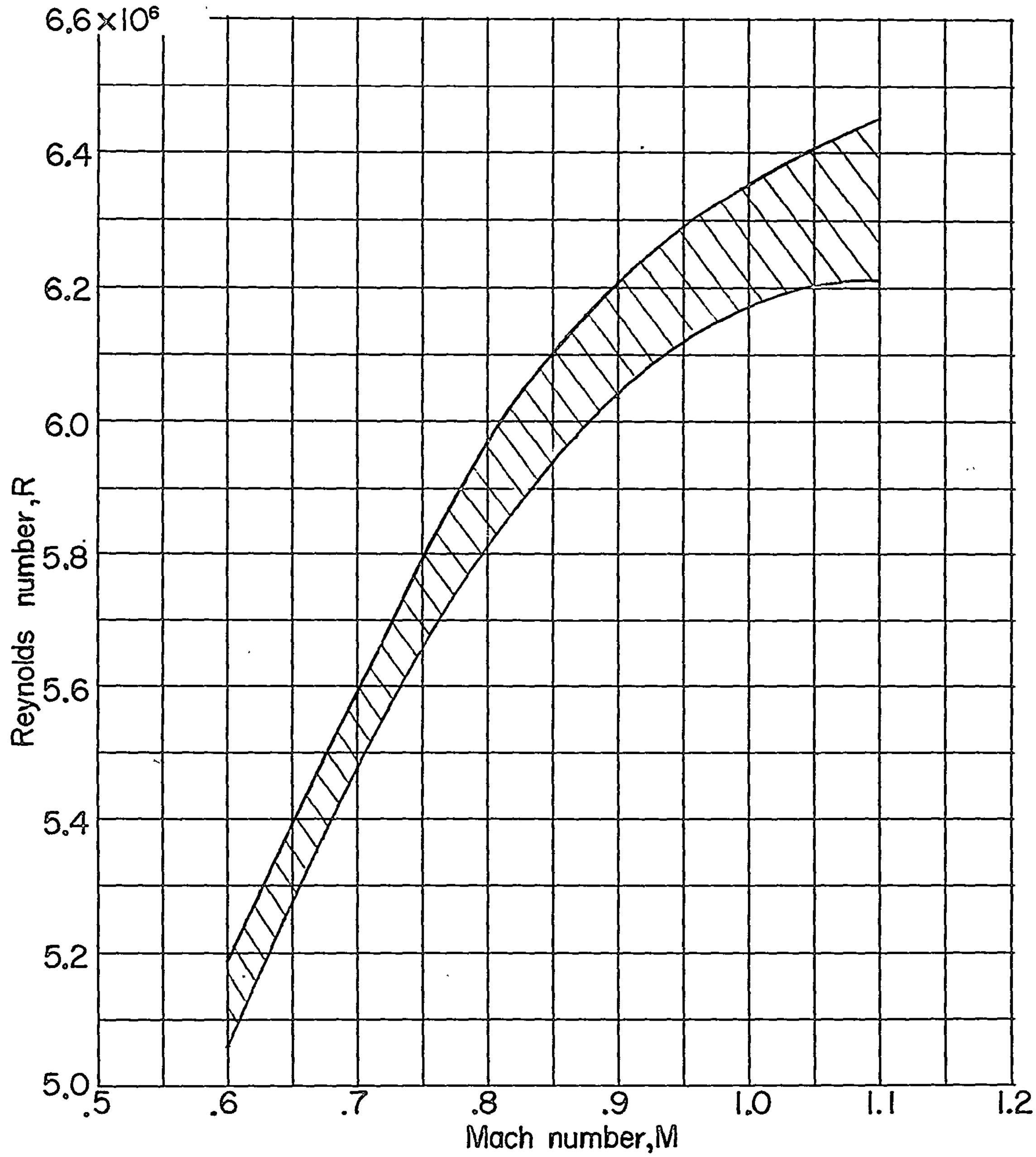
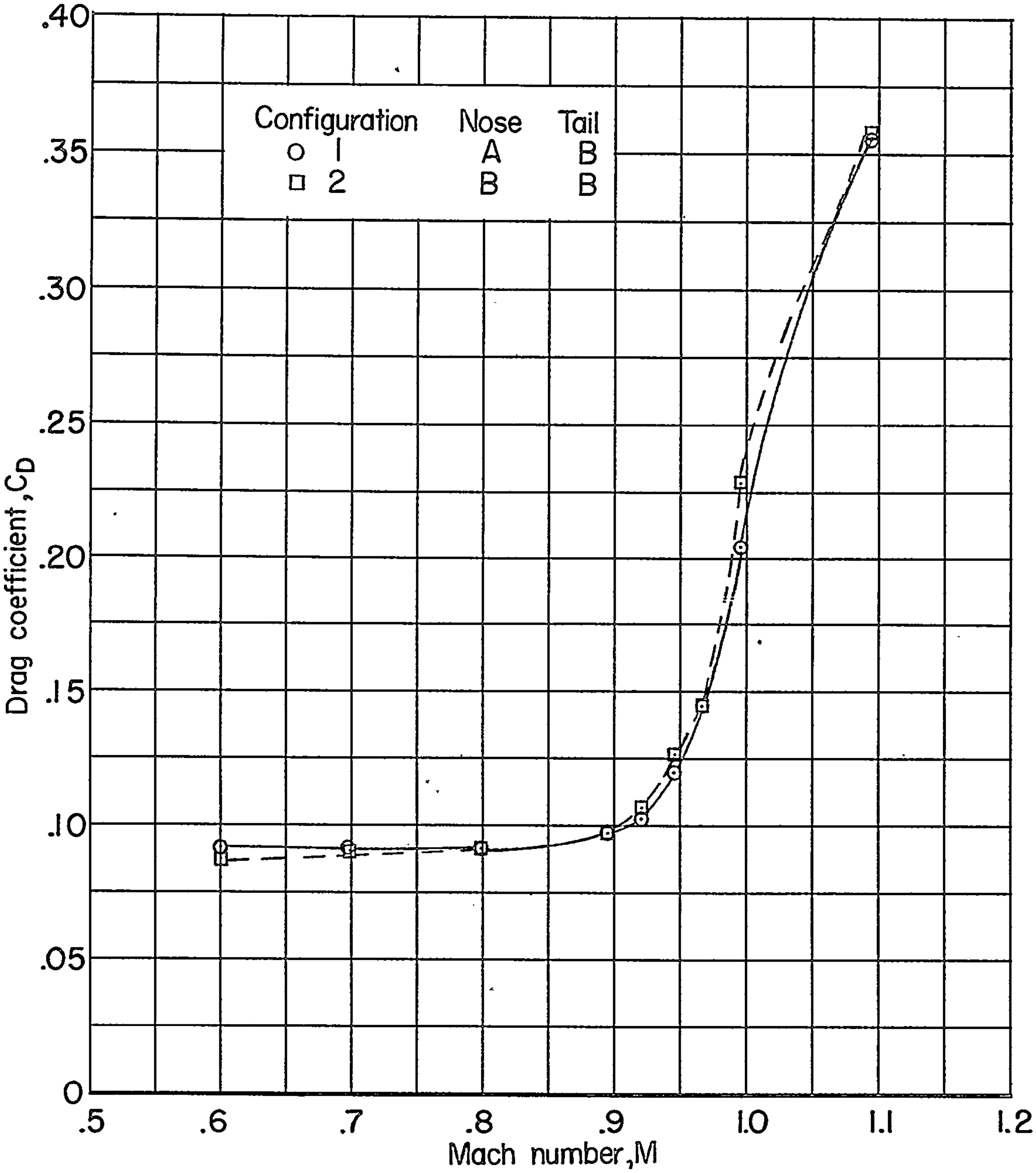
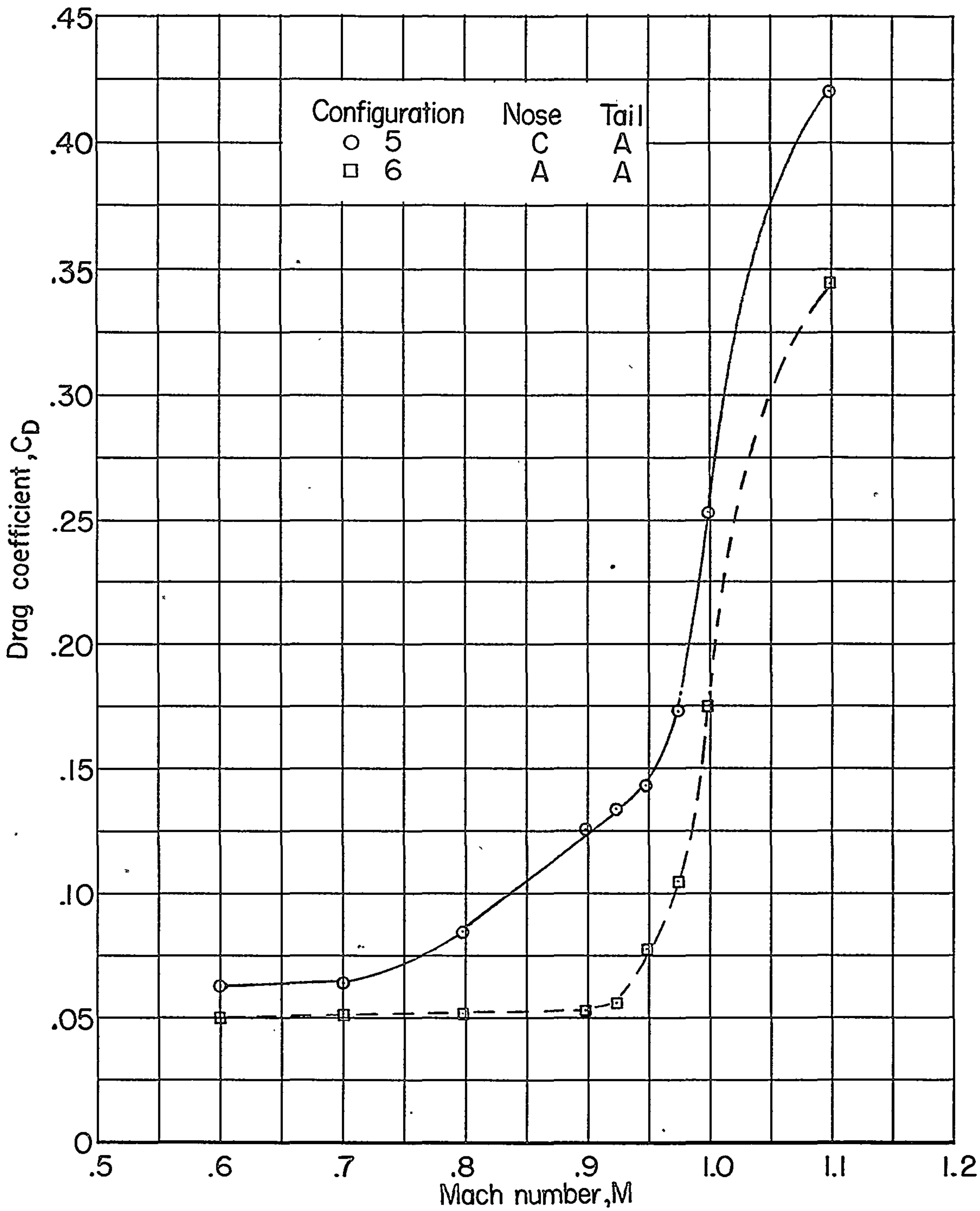


Figure 4.- Variation of Reynolds number based on body length with Mach number.



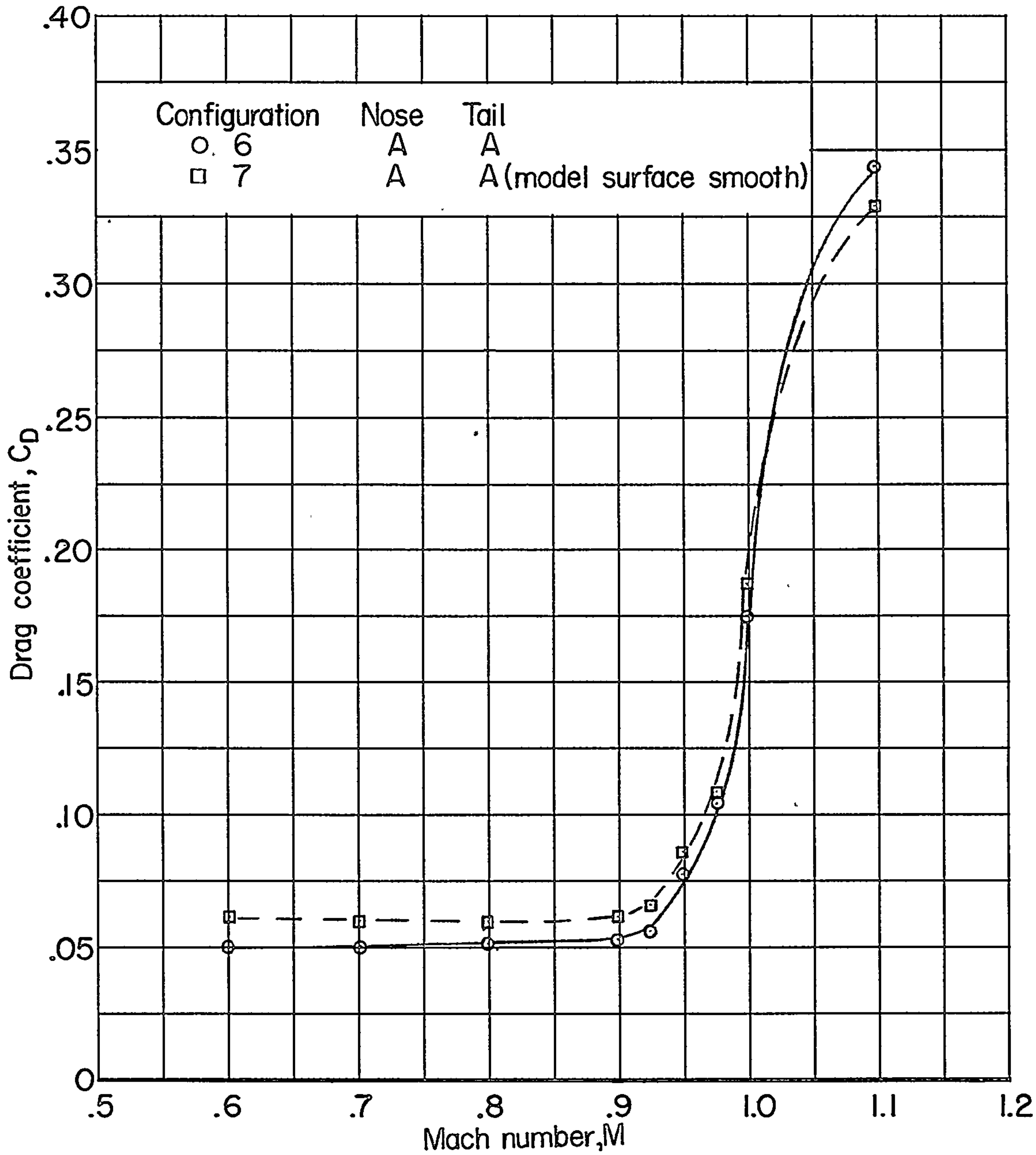
(a) Configurations 1 and 2.

Figure 5.- Variation of zero-lift drag coefficient with Mach number for test configurations with different nose shapes.



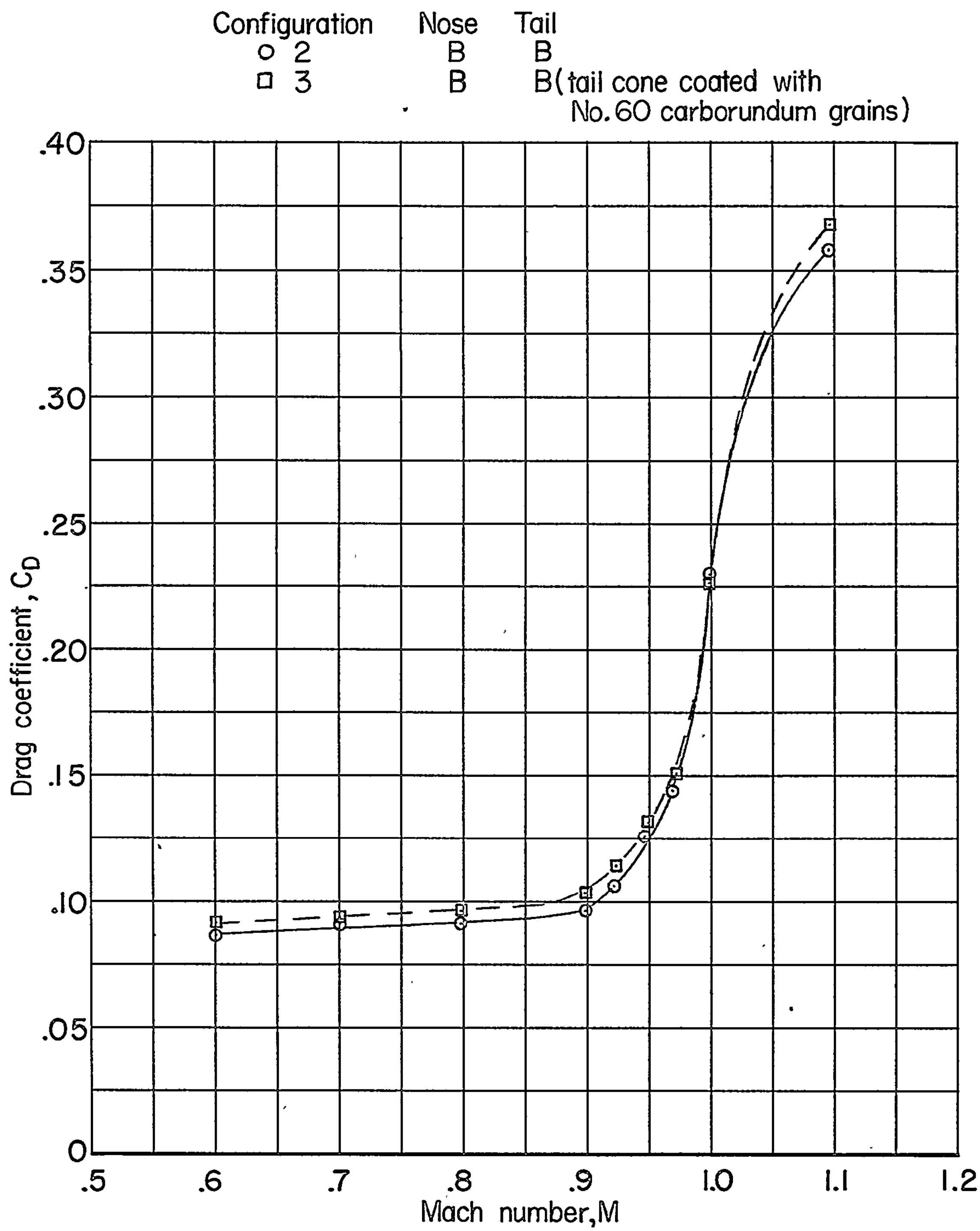
(b) Configurations 5 and 6.

Figure 5.- Concluded.



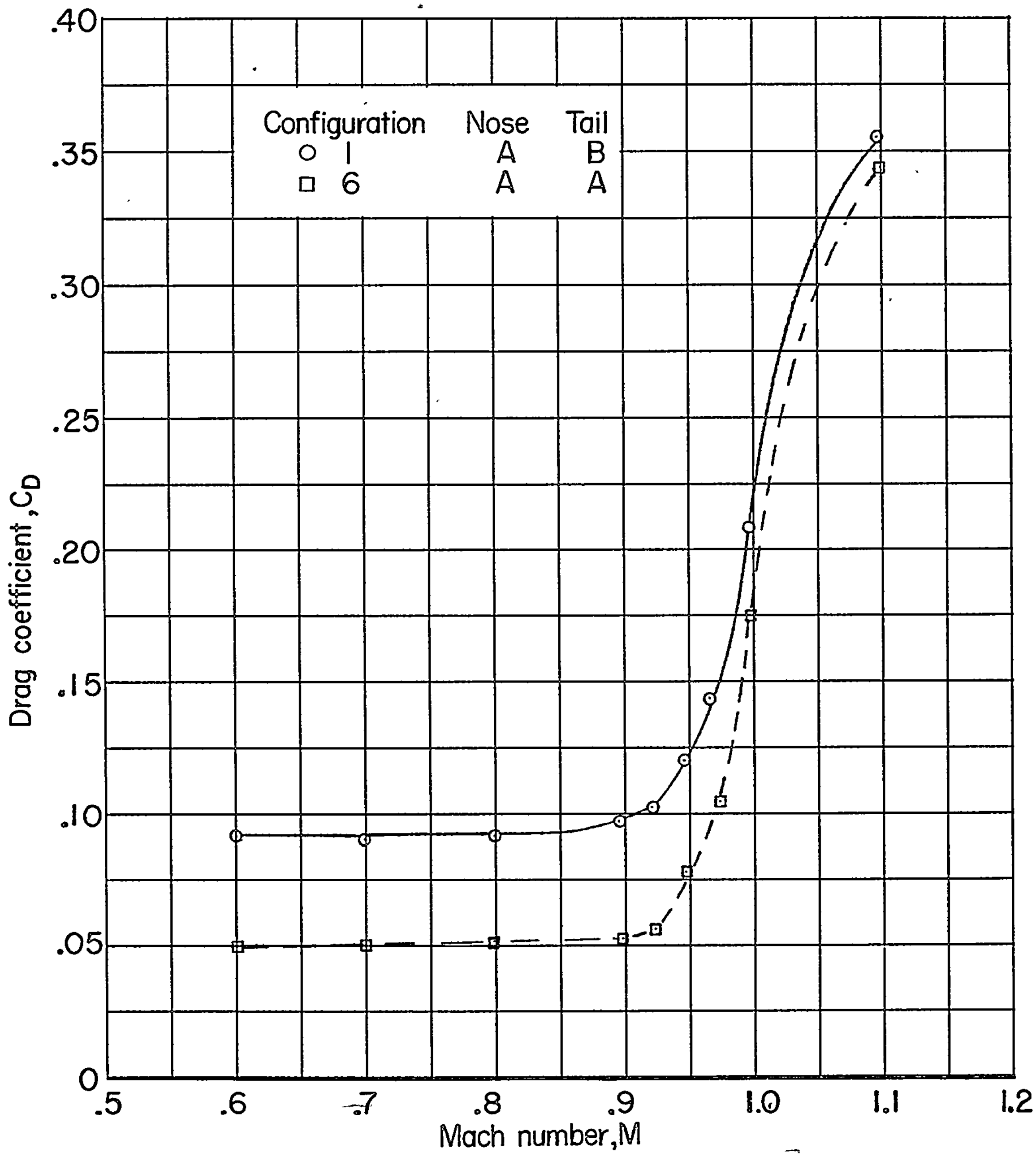
(a) Configurations 6 and 7.

Figure 6.- Variation of zero-lift drag coefficient with Mach number for test configurations with different surface roughnesses.



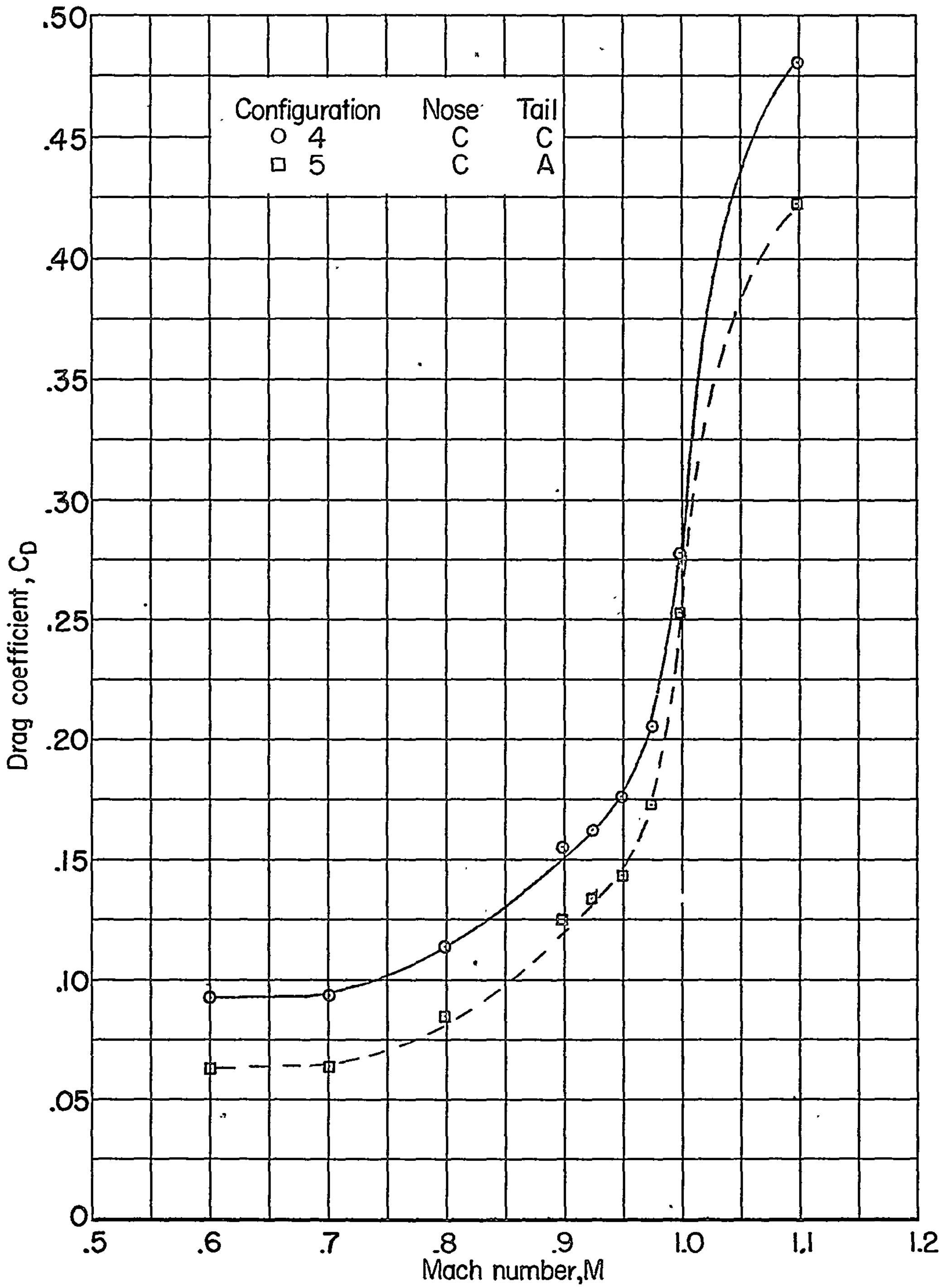
(b) Configurations 2 and 3.

Figure 6.- Concluded.



(a) Configurations 1 and 6.

Figure 7.- Variation of zero-lift drag coefficient with Mach number for test configurations with different tail fins.



(b) Configurations 4 and 5.

Figure 7.- Concluded.

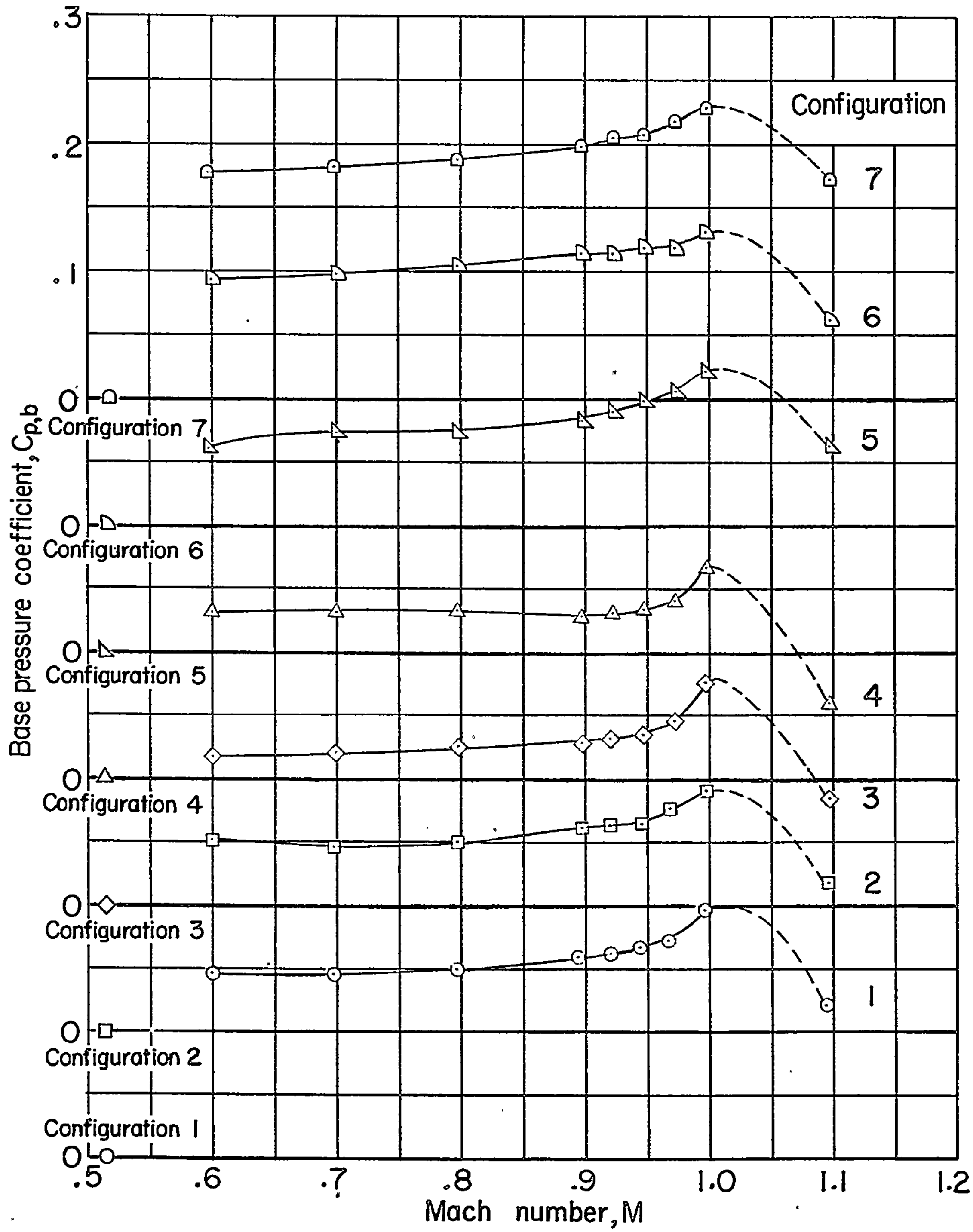


Figure 8.- Variation of base pressure coefficient with Mach number.

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ABSTRACT

Zero-lift drag data were obtained in the Langley 8-foot transonic wind tunnel for several practice bomb configurations at Mach numbers from 0.60 to 1.10. Seven configurations were tested with different nose shapes and with different tail cones with fins. Body and tail-cone surface conditions were varied for some tests. The Reynolds number varied from 5.190×10^6 to 6.453×10^6 during the investigation.

INDEX HEADINGS

Bodies - Surface Conditions	1.3.2.4
Tail-Body Combinations - Missiles	1.7.2.1.2
Missiles, Specific Types	1.7.2.2

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